Capital Requirements and Shifts in Commercial Bank Portfolios

by Joseph G. Haubrich and Paul Wachtel

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Introduction

A dramatic and virtually unprecedented shift in the portfolio structure of U.S. commercial banks has taken place since 1989. Specifically, government securities as a share of total loans has risen from 15 percent in 1989 to more than 22 percent today. This portfolio shift has coincided with an important change in the financial regulatory structure. Bank regulators around the world agreed to a common set of risk-based capital requirements in mid-1988. These requirements were phased in gradually in the United States and became fully effective this year.

Some have suggested a connection between the regulatory changes and the portfolio shift, although this claim has not been substantiated. In this paper, we will present some rather strong evidence that the portfolio shift is consistent with regulatory change, which has increased the attractiveness of government securities as an asset.[1] The evidence comes from an examination of the quarterly "call report" data on commercial banks from the Federal Financial Institutions Examination Council (FFIEC).

Though bankers and their regulators find the portfolio shift interesting in itself, it also has broader implications. Our results provide evidence that regulation matters—a point of considerable debate for capital requirements in particular (Keeley [1988]) and for public policies in general (Stigler [1975]). The reason is that bank portfolio risk strongly affects the chance of financial collapse and an associated government bailout. Concerns about this possibility motivated the risk-based capital standards in the first place. Furthermore, by altering the credit available to businesses and consumers, a shift in bank portfolios may slacken the pace of economic recovery.

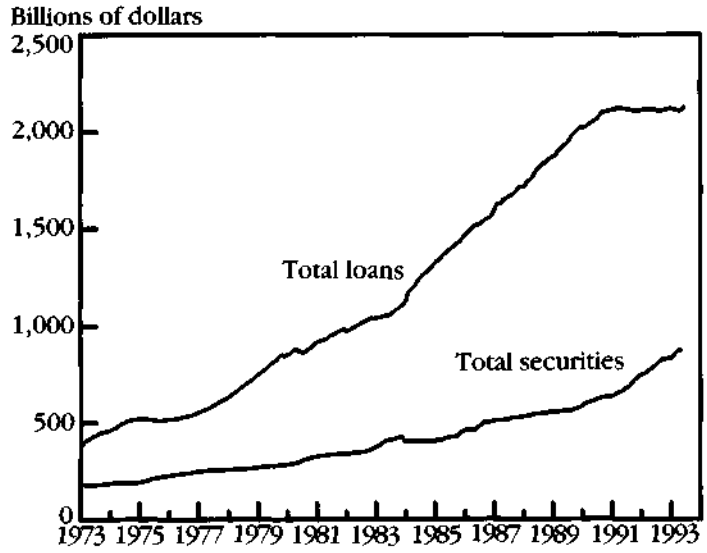
The new risk-based capital requirements classify bank assets. Government securities are deemed to be riskless and therefore have a zero weight when the bank determines its required capital.[2] Thus, a bank that finds it difficult to meet its capital requirements can do so by shifting its asset portfolio away from loans and other high-risk-weighted assets toward government securities.

■ 1 For some other interesting approaches to the same problem, see Furlong (1992), Jacklin (1993), and Hancock and Wilcox (1992).

■ 2 U.S. government securities have a zero risk weight because there is no default risk. However, they are subject to interest-rate risk, and the new capital requirements have been criticized for ignoring this component.

FIGURE 1

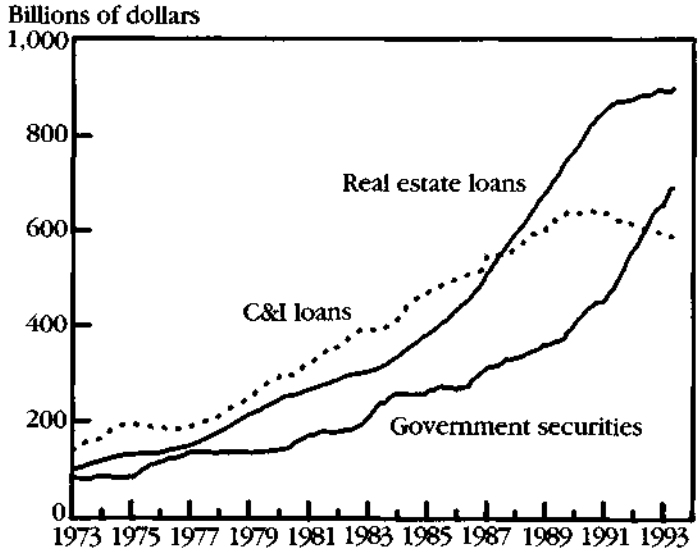
Growth in Loans and Securities for Commercial Banks, 1973–93



SOURCE: Board of Governors of the Federal Reserve System, statistical release G.7.

FIGURE 2

Growth in Government Securities, C&I Loans, and Real Estate Loans for Commercial Banks, 1973–93



SOURCE: Board of Governors of the Federal Reserve System, statistical release G.7.

There are, of course, other plausible reasons why bank portfolios have shifted toward government securities. First, the large loan losses of the 1980s made business lending appear more risky and less attractive. Second, the business slowdown that coincided with the introduction of risk-based capital requirements weakened loan demand. The decline in loan demand was exceptionally large in the recent recession because of the boom in business and consumer leverage in the mid-1980s. Thus, the shift toward government securities could also be the result of these factors.

We submit that the changes in portfolio composition are strongly related to the introduction of risk-based capital requirements. Specifically, banks with the largest increases in government securities holdings tend to be those with the lowest capital–asset ratios when the new capital requirements were introduced. The conclusion is unaffected when we control for the weakness of the bank's loan portfolio.[3] Thus, the change in bank portfolios does not seem to be the result of this weakness.

I. Aggregate Trends in Bank Assets

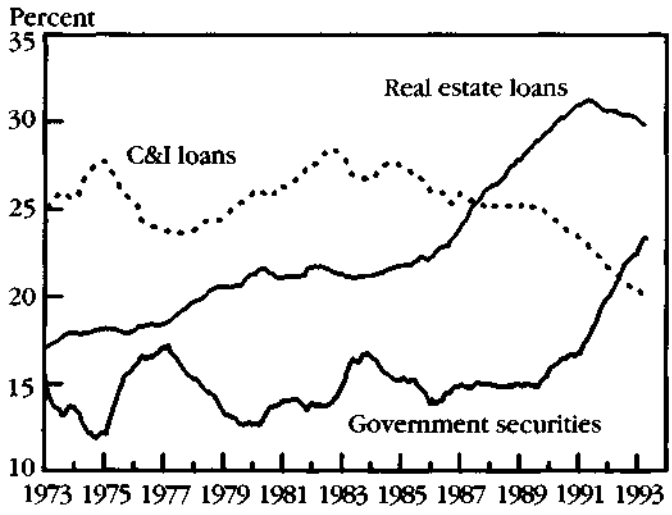
The composition of commercial bank portfolios has changed dramatically over the years. For the first two postwar decades, banks reduced the proportion of their assets in securities and increased the proportion in loans. Part of the reason was the need to liquidate large holdings of government securities accumulated during World War II. Moreover, the development of highly liquid and active money markets as sources of funds reduced the precautionary need to hold both government securities and cash assets (see Boyd and Gertler [1993]). These secular shifts in banks' activities were completed by the early 1980s.

Some dramatic changes have taken place more recently, however. Figure 1 shows the growth of total loans and total securities since 1973. After rapid gains beginning in 1973, the outstanding stock of bank loans has been constant for the last three years. Total securities holdings expanded less rapidly through the 1980s and began to speed up in the last three years.

■ 3 It is more difficult to control for the influence of loan demand on portfolio shifts because we lack any bank-specific measures of the strength of demand. Still, while other factors may explain part of the portfolio shift, they do not overturn the importance of the new capital requirements.

FIGURE 3

Government Securities, C&I Loans, and Real Estate Loans as a Share of Total Loans and Securities, 1973–93



SOURCE: Board of Governors of the Federal Reserve System, statistical release G.7.

More detail is provided in figure 2, which shows three critical categories—government securities, commercial and industrial (C&I) loans, and real estate loans. The rapid increase in government securities holdings since the late 1980s has clearly coincided with a substantial decline in the volume of C&I loans outstanding.

Finally, figure 3 presents the proportions of these three critical categories in total loans and securities. The share of C&I loans began to decline around 1984. Real estate loans as a percent of the total began to increase in 1986 and then leveled off around 1990. Most important, the proportion of U.S. government securities in total loans and securities rose dramatically in the three years following 1989. The bank portfolio shifts of the last decade thus occurred in two stages: Banks initially turned from C&I loans to real estate loans, but then shifted from loans to U.S. government securities in recent years.

II. Changes in Bank Portfolios

Regulation mandating commercial-bank capital requirements has evolved over the years. In 1985, regulators established a required ratio of book value of equity (primary capital) to assets of 5.5 percent. There was also a total capital requirement of 6 percent for the ratio of primary and secondary capital to assets. U.S. and foreign regulators agreed in 1988 to implement risk-based capital requirements. The new requirements were phased in gradually beginning in 1990 and became fully effective at the end of 1992 (see Saunders [1993]).

U.S. commercial banks are now required to have a minimum ratio of total (Tier 1 + Tier 2) capital to risk-adjusted assets of 8 percent.[4] In order to calculate risk-adjusted assets, each asset is assigned to one of four risk categories and given a weight of 0, 20, 50, or 100 percent. U.S. government securities are in the first category, with a risk weight of zero. C&I loans and most real estate loans (except securitized mortgage pools and regular residential mortgage loans) are assigned a weight of 100 percent. Risk-adjusted assets are thus simply a weighted average of the bank's portfolio of assets. In addition, the entire portfolio faces a leverage restriction: Total capital must be 4 percent of total assets (unweighted).[5]

Thus, a commercial bank that moves its asset holdings from loans with a full 8 percent capital requirement to government securities with no capital requirement eases the associated regulatory burden. Clearly, banks that are inadequately capitalized have an incentive to increase the proportion of their assets in government securities. Our central hypothesis is simply that the large changes in bank balance sheets observed in the last three years represent a response to these incentives.

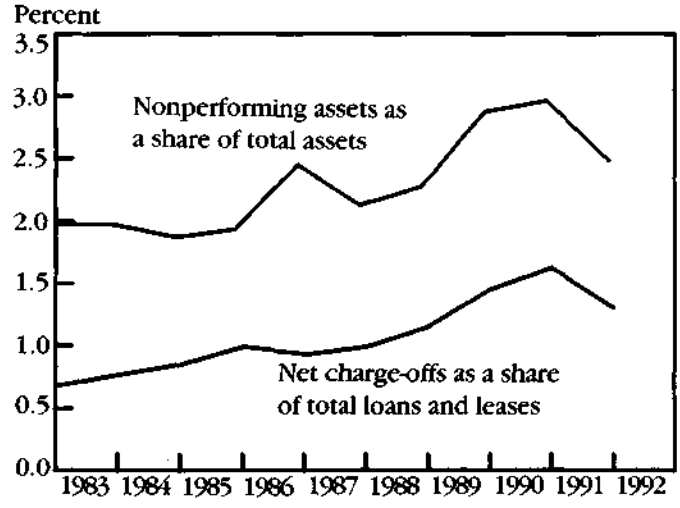
One alternative hypothesis is that the shift into government securities was an effort to avoid risk as bank asset portfolios weakened in general. Because banks found it more difficult to manage their risky asset portfolios, they viewed government securities more favorably, and there was a flight to quality. This hypothesis is credible in light of the documented deterioration in the condition of commercial bank portfolios in the 1980s.

■ **4** The minimum ratio of Tier 1 capital (primarily common stock equity) to risk-adjusted assets is 4 percent. Tier 2 capital includes certain types of preferred stock and subordinated debt. The details of the new rules are published in the *Federal Register*, January 27, 1989, pp. 4186–221.

■ **5** The Basel agreements themselves specify only Tier 1 risk-based and total risk-based ratios. Outside the United States, banks face only those capital requirements. U.S. banks have an additional constraint: minimum leverage. While the capital guidelines implementing the Basel Accord specified a constraint of 3 percent, the prompt corrective action guidelines of the FDIC Improvement Act of 1991 (FDICIA) mandated a constraint of 4 percent, except for banks with a regulatory CAMEL rating of 1. For a discussion, see Huber (1991), chapter 15, or Carnell (1992).

FIGURE 4

Nonperforming Assets and Net Charge-offs as a Share of Totals, 1983–92



SOURCE: Federal Deposit Insurance Corporation.

This downtrend is illustrated in figure 4. Nonperforming assets as a percent of total assets and net charge-offs as a share of total loans and leases both began to rise in the mid-1980s. However, this portfolio deterioration preceded the change in asset composition by several years. The shift of assets into government securities started in the late 1980s when banks' condition began to recover. The increasing net charge-off rate and nonperforming loan rates in 1990 and 1991 stemmed not from an upturn in bad loans, but rather from a decline in total loans outstanding.

As a final check, we control for the effects of loan quality in section V. Though we cannot rule out this factor, our results do indicate a risk-based capital effect independent of loan quality.

An alternative explanation is that the change in bank portfolios was related to loan demand and overall economic conditions. Indeed, cyclical changes in bank portfolio preferences are quite common. For example, when monetary policy eased in the mid-1970s and again at the end of the 1980–82 recessions, the government securities proportion of total loans and securities headed upward. The episode in the early and mid-1980s is similar to the current situation. Although monetary policy eased, banks were reluctant to boost lending, and the proportion of government securities in their portfolios increased. At that time, the debt crisis in less-developed countries influenced bank behavior. In both of the earlier cases, however, a growing economy generated loan demand and the run-up in government securities holdings lasted only about two years.

In the recent episode, the rise in government securities holdings has continued for almost four years without any sign of abatement, placing the proportion of these securities in commercial bank portfolios at unprecedented levels. This situation may be unique because the recovery that began two years ago has been particularly sluggish. Despite an expansionary monetary policy, the persistently weak economy has held down loan demand, and as a result, banks continue to augment their holdings of government securities. Although it is difficult to distinguish between the effects of weak loan demand or risk-based capital requirements on bank holdings of government securities, a cyclical response to demand is unlikely to be entirely responsible for the enormous portfolio shifts observed.

A third alternative is that government securities became more profitable in the late 1980s. The combination of a steep yield curve and a large supply of government securities, driving prices down, may have made banks eager customers. This term-structure argument requires more justification than is usually given: Many bank loans are long term, and thus could also be profitable for banks.

The story appears to rest on some shift not in the term structure, but in the risk structure, between Treasury bonds and bank loans. This is less obvious than the initial statement, however. Perhaps the explosion in government debt drove down the price of Treasuries (though this point itself is controversial). In either case, such general factors should not affect individual banks differently. Therefore, our strategy of comparing well-capitalized and weakly capitalized banks is not sensitive to this shift. The lower prices for Treasuries may explain the portfolio shift of well-capitalized banks.

III. Relationship between Capital and Portfolio Shifts

Our hypothesis indicates that a bank's incentive to satisfy the newly introduced risk-based capital requirements by adjusting its portfolio is larger if the institution initially fails those new requirements. That is, banks that will be capital constrained under the new standard if they

TABLE 1

Asset Allocations for Commercial Banks by Size Class, March 1990 (percent)

Proportion of Total Assets Held as:	Size Class 1	2	3	4	5	6
Cash assets	8	6	6	7	8	10
Total securities	30	30	26	19	19	15
Treasuries (book value)	10	9	8	6	5	4
Total loans	51	54	59	65	65	65
C&I loans	9	11	13	16	18	21
Real estate loans	30	30	30	28	24	19
Mortgages (1–4 family)	13	14	14	11	9	7
Consumer loans	11	12	14	17	17	14

SOURCES: Federal Financial Institutions Examination Council, Quarterly Reports on Income and Condition; and authors' calculations.

TABLE 2

Capital Ratios by Size Class, March 1990–September 1992 (percent)

	Size Class 1	2	3	4	5	6
A. Capital Ratios and Changes						
Total capital/ risk-adjusted assets, March 1990	18.38	16.41	13.95	11.44	10.82	8.67
Change, 1990–92	0.12	1.14	1.27	1.41	1.45	2.71
Tier I capital/ risk-adjusted assets, March 1990	17.20	15.27	12.77	10.04	9.38	6.79
Change, 1990–92	0.12	1.09	1.21	1.37	1.28	2.37
B. Distribution of Banks by Capital Class, March 1990						
Capital Class						
0–4%	6.8	0.5	0.6	1.0	0.0	0.0
4–8%	2.2	2.1	3.6	10.9	14.6	32.4
8–10%	3.7	5.8	12.9	28.8	37.7	53.3
10–14%	23.7	33.6	44.9	46.7	40.4	11.4
>14%	63.6	58.0	38.0	13.5	7.3	1.9

SOURCES: Federal Financial Institutions Examination Council, Quarterly Reports on Income and Condition; and authors' calculations.

do nothing will thus take greater actions to comply. In this section, we present the data used to examine the relationship between the initial risk-based capital ratio of individual banks (in either 1988 or 1990) and the banks' portfolio changes. Our data source is the quarterly call reports on all U.S. commercial banks. In addition, we show that a bank's incentive to hold government securities increases even if it was not initially capital constrained.

Although the risk-based capital requirements were announced in July 1988 and began to be implemented in March 1989, the call reports were not revised to reflect the new definitions until March 1990. Prior to 1990, however, it is possible to approximate the risk-based capital ratio of the bank from the available data. In both instances, we use algorithms developed at the Federal Reserve Board by Avery and Berger (1991) to derive the risk-adjusted assets of the bank. Thus, we will be able to look at the changes in bank portfolios over two periods: from June 1988 (when the new capital requirements were announced) to September 1992, and from March 1990 (when the phase-in of the new capital requirements began) to September 1992.

Our data set consists of 12,187 commercial banks divided by asset size (as of March 1990) as follows:[6]

1. Less than $50 million	6,558
2. $50–100 million	2,685
3. $100–500 million	2,350
4. $500 million–1 billion	229
5. $1–5 billion	260
6. More than $5 billion	105

Table 1 shows that commercial bank asset allocations differ according to bank size. For example, the smallest banks had only 9 percent of their assets in C&I loans, while the proportion for the largest banks was 21 percent. However, the asset allocation changes that occurred over the two-and-a-half-year period beginning in March 1990 were common to all sizes of banks (the very smallest were sometimes an exception). Holdings of securities, particularly Treasury securities, rose and loans (except for real estate loans) decreased.

The top part of table 2 shows the ratios of capital to risk-adjusted assets at the start of the period and the change for banks in each size class over the sample period. On average,

■ 6 Banks were removed from the sample if the data seemed to be erroneous, if extreme outliers were present, or if the banks had greater than 50 percent capital.

TABLE 3

Bank Adjustment to Risk-Based Capital Requirements: Portfolio Shifts, Growth, and Raising Capital

Capital Class	Size Class 1	2	3	4	5	6
	Portfolio Shift $\hat{P}$					
0	−0.08	0.59	−0.20	—	—	—
1	−0.11	−0.10	−0.13	−0.14	−0.10	−0.08
2	−0.06	−0.10	−0.06	−0.08	−0.08	−0.07
3	−0.01	−0.03	−0.03	−0.02	−0.06	0.00
4	0.06	0.01	0.01	0.07	0.30	−0.10
	Size Shift $\hat{TA}$					
0	0.87	0.70	−0.20	—	—	—
1	0.09	0.01	0.15	0.04	0.17	0.00
2	0.24	0.38	0.20	0.19	0.20	0.10
3	0.25	0.28	0.22	0.16	0.20	0.27
4	0.31	0.19	0.19	0.36	0.10	0.28
	Capital Shift $\hat{C}$					
0	48.55	12.01	2.42	—	—	—
1	0.89	0.46	0.48	0.35	0.56	0.34
2	0.47	0.48	0.30	0.31	0.30	0.30
3	0.32	0.31	0.28	0.20	0.22	0.30
4	0.24	0.20	0.21	0.24	0.15	0.29

SOURCES: Federal Financial Institutions Examination Council, Quarterly Reports on Income and Condition; and authors' calculations.

banks of all sizes were sufficiently well capitalized; the minimum total capital requirements were 8 percent. Finally, in every size class, banks augmented capital in this period.

To explore the relationship between portfolio changes and capital requirements, we classified banks by total capital to risk-adjusted asset groups at the start of the period. The capital requirement classes and the distribution of banks by size class are shown in the bottom part of table 2. Most smaller banks had very high capital–asset ratios, although there were a significant number of exceptions. As bank size increases, the proportion of banks with capital ratios under 8 percent rises as well. When we reach the largest size class, very few banks exceeded the minimum capital requirement by a comfortable margin.

Under this classification scheme, banks that are severely undercapitalized (0 to 4 percent capital ratio) or moderately undercapitalized (4 to 8 percent capital ratio) must meet the new requirements to stay in business. They may downsize, raise new capital, or rebalance their portfolios to take advantage of the different risk weights. The explicitly undercapitalized banks are not the only ones facing incentives to increase their capital, however. Regulators require banks to hold capital well in excess of the minimum requirements in order to expand or to be able to acquire new entities or businesses.[7] A bank that just satisfies the 8 percent minimum capital ratio and wishes to sell mutual funds, for example, would probably need to increase its capital ratio before obtaining regulatory permission.

To assess how banks responded to the new capital requirements, we explore the nature of capital. Capital satisfies the following identity:

(1) Capital = (capital/risk-weighted assets) x (risk-weighted assets/total assets) x total assets.

In other words, $C = R \times P \times TA$, where C = capital, R = the risk-weighted capital ratio, P = the portfolio factor, and TA = total assets.

Using the standard circumflex notation for proportionate changes ($\hat{C} = \frac{\Delta C}{C}$), we get $\hat{C} = \hat{R} + \hat{P} + \hat{TA}$, or

$$(2) \quad \hat{R} = \hat{C} - \hat{P} - \hat{TA}.$$

Because the risk-adjusted capital requirements are a constraint on R, we see that equation (2) descriptively allocates the adjustment of banks to three possible courses of action: raise capital (increase C), adjust the portfolio (lower P), or shrink total assets (lower TA). Table 3 reports this breakdown.

Three patterns stand out in table 3. Banks did shift their portfolios in a way that reduced their capital requirements. Furthermore, this shift was more pronounced for undercapitalized banks at every size level. Banks likewise responded by raising capital, although the well-capitalized banks apparently raised more. Finally, on average, banks did not shrink, and in fact grew over this period in every size and capital class. These patterns confirm our primary emphasis on the portfolio effects of the new capital requirements.

■ 7 FDICIA directs bank regulators to use the risk-based capital requirements in making supervisory decisions. The Act established five categories based primarily on the bank's capital position. To be considered well capitalized, a bank would have to exceed the minimum capital requirements by a substantial margin. We caution the knowledgeable reader that the capital classes we use are *not* FDICIA prompt-corrective-action zones.

BOX 1

Why ANOVA?

Though commonly used in many areas of statistics, analysis of variance (ANOVA) is less popular among economists, who generally prefer regression analysis. For evaluating bank portfolio shifts, however, ANOVA has several advantages.

First, it does not require assumptions about the nature of the functional form of the statistical relation: In particular, it does not impose a linear relation between capital and portfolio shifts. A difference in the response of well-capitalized and undercapitalized banks assumes a nonlinear response by definition. The different degrees of capital constraint (for example, deeply undercapitalized, barely capitalized) coupled with our ignorance about the correct form of the relation (linear, logarithmic, quadratic) make the ANOVA specification particularly attractive.

ANOVA might also be called "comparison of means." It statistically estimates the effects due to various factors (here, they are size and capital class) and then allows comparison of those effects—analyzing how and why the cells of table 6 differ from each other.

ANOVA has a further advantage in that it facilitates the estimation and interpretation of interaction effects. Our analysis considers two *main effects*, size and capital. Accounting for each one separately may not provide the whole story: The main effects may not be additive, and there may be interaction effects. For example, undercapitalized large banks may receive more scrutiny from the regulators or find it easier to invest in certain markets, and so may adjust their portfolios differently.

Banks had another reason to adjust portfolio shares. The new requirements changed the returns on different types of investments. Relative to business and commercial real estate loans, government securities became more profitable because they required less capital backing. A simple calculation shows that the difference can be substantial.

The standard way to approach these issues is with a version of the Miller (1977) debt model as extended to banks by Orgler and Taggart (1983). Banks have two sources of funds: deposits and equity. Deposits have a tax advantage in that banks may deduct interest paid as a business expense, but cannot deduct dividends paid on equity. Deposits have an additional cost of reserve requirements, but in general banks would prefer to raise funds using debt. Banks cannot fund themselves exclusively with deposits, however, because they face a constraint on their funding, namely a capital requirement that the ratio of debt (for example, deposits) to equity not exceed a limit ζ. If we denote the return on deposits as r_d and the return on equity as r_e, the marginal cost of raising funds, r, is given by

$$(3) \qquad r = \frac{r_e/(1-t) + \zeta\, r_d}{1 + \zeta(1-\rho)},$$

where t is the corporate tax rate and ρ is the reserve requirement. The bank lends until the return on the loan equals the cost of funds needed to fund the loan.[8]

The capital requirements impose a different ζ on different assets, and thus induce a different rate of return. As an example, consider a return on equity r_e of 10 percent, a return on deposits r_d of 4 percent, a corporate tax rate t of 28 percent, and required reserves ρ of 12 percent. A U.S. Treasury bond has a ζ of 24 (a zero risk weighting and the 4 percent leverage requirement that becomes a debt-to-equity ratio of 0.96/0.04), while a C&I loan has a ζ of 11.5 (a 100 percent risk weighting). In this case, the cost of raising funds internally (r_i) to buy a Treasury bond is 4.9 percent, while the cost of raising funds internally to make a loan is 5.4 percent. The relative cost of loans has increased, making their inclusion in a portfolio less attractive.[9]

IV. Analysis of Variance

The relationship between portfolio changes and the risk-adjusted capital ratio prior to the introduction of risk-based capital requirements is examined with an analysis of variance (ANOVA, detailed in box 1). We investigate the relationship for the asset categories outlined in table 4.

■ **8** A little more intuition on the exact form of equation (3) can be gained as follows. Assume that the bank wishes to raise one dollar as cheaply as possible. The bank would like to use debt, for which it pays r_d, but it faces a capital constraint, so it can raise only a fraction of the funds using debt. It also must raise equity, and must pay more than r_e because of corporate income tax. This explains the first term in the numerator. Because the bank raises money from two different sources, the actual cost is a weighted average of the cost of funds from those sources, and a little algebra shows that the $1/1 + \zeta$ and $\zeta/1 + \zeta$ terms provide the proportion of equity and debt to total assets. Finally, some of the debt must be invested in required reserves, so to invest one full dollar, the bank must raise slightly more than that, which accounts for the ρ term in the denominator.

■ **9** The general situation is more complicated, of course. For example, some banks can meet their capital requirement by increasing their Tier 2 capital. This includes subordinated debt, which despite being more expensive than deposits avoids the corporate tax penalty of equity.

TABLE 4

Proportion of Total Assets (percent)

	March 1990	September 1992
Cash assets	7.3	6.0
Total securities	28.7	31.7
Treasuries	9.3	10.3
Other securities	19.3	21.4
Total loans	53.8	54.2
C&I loans	11.0	9.3
Mortgages (1–4 family)	13.2	14.5
Other loans (includes other real estate)	29.6	30.4

SOURCE: Authors' calculations.

TABLE 5

Analysis of Variance Results—Probability that Observed Effect is Due to Chance

Difference across Classes by:	Size and Capital	Size	Capital
Asset Changes, 1988–92			
Cash assets	0.003	0.0017	0.0384
Total securities	0.0	0.0	0.8049
Treasuries	0.0	0.0	0.3661
Other securities	0.0047	0.0003	0.7267
Total loans	0.0	0.0	0.0072
C&I loans	0.0	0.0	0.0005
Mortgages	0.178	0.708	0.9200
Other loans	0.0	0.0	0.0894
Asset Changes, 1990–92			
Cash assets	0.2578	0.9709	0.0215
Total securities	0.0	0.0	0.6090
Treasuries	0.0	0.0	0.0176
Other securities	0.006	0.0	0.2811
Total loans	0.0	0.0	0.0003
C&I loans	0.0	0.0	0.0017
Mortgages	0.1553	0.1272	0.6553
Other loans	0.0	0.0	0.0270

SOURCE: Authors' calculations.

The ANOVA was performed for the change in the ratio to total assets for each category for two time periods. The first period begins in June 1988, just before the risk-based capital requirements were announced, and the second one starts in March 1990, the first available data after the requirements were phased in. This process shows whether the changes in the asset ratios differ significantly across size or capital classes.

The ANOVA F-tests for the effects of size and capital class are summarized in table 5, which presents the probabilities at which the null hypothesis of no significant effect can be rejected. That is, it gives the probability that all effects of the given type are zero. The first column provides the overall test on all the effects and interactions. The next two columns are tests that depend on the ordering of the variables. The second column tests for the significance of the size effects alone. This test is based on the sum of squares, putting the size effect in the estimation first. The third column is a stringent test for the significance of the capital class effects. It is based on the sum of squares when the capital class is added last; it tests the significance of the additional effect of this variable, having already controlled for the size and interaction effects.[10]

In most instances, there are significant differences in asset changes among banks of various size classes. This reflects a wide divergence in portfolio allocations between large and small banks. More important, the differences across capital classes are significant even at the 5 percent level for only a handful of asset categories.

For the asset changes between 1988 and 1992, there are substantial differences across risk-adjusted capital ratio classes for only cash assets and C&I loans. The changes in Treasury-to-total-asset ratios do not vary much across capital ratio classes ($p = 0.3661$). However, when we examine changes from the introduction (rather than the announcement) of the risk-based capital requirements, 1990 to 1992, additional significant changes arise. For this period, the changes in the Treasury-to-asset ratios vary widely by capital ratio class ($p = 0.0176$). In addition, there are substantial differences at the 5 percent level for cash assets, C&I loans, mortgages, and other loans.

The ANOVA results indicate a strong relationship between the initial capital ratio and

10 For a theoretical background, see Searle (1971); for a discussion of the tests, see the SAS/STAT User's Guide (1990), chapters 9 and 24. The SAS system refers to the last two columns in table 5 as type I and type III tests.

TABLE 6

Change in Selected Asset Ratios, 1990–92

Capital Class	Size Class 1	2	3	4	5	6
	Government Securities					
0–4%	0.04	0.03	0.09	0.00	0.00	0.00
4–8%	0.04	0.03	0.03	0.02	0.03	0.03
8–10%	0.03	0.02	0.02	0.03	0.02	0.02
10–14%	0.01	0.02	0.02	0.02	0.03	0.02
>14%	−0.01	0.00	0.01	−0.02	0.01	−0.03
	Cash					
0–4%	−0.01	0.00	0.01	—	—	—
4–8%	−0.01	−0.01	−0.01	0.00	−0.01	−0.01
8–10%	−0.01	−0.01	−0.01	−0.01	−0.01	−0.01
10–14%	−0.01	−0.01	−0.01	−0.02	−0.01	−0.01
>14%	−0.01	−0.01	−0.01	−0.02	−0.04	−0.07
	C&I Loans					
0–4%	−0.05	−0.02	−0.05	—	—	—
4–8%	−0.03	−0.03	−0.05	−0.04	−0.04	−0.02
8–10%	−0.03	−0.03	−0.04	−0.03	−0.04	−0.03
10–14%	−0.02	−0.02	−0.03	−0.03	−0.03	−0.02
>14%	−0.01	−0.01	−0.02	−0.01	−0.01	−0.02
	Mortgages					
0–4%	−0.00	0.02	−0.02	—	—	—
4–8%	0.01	0.02	0.02	−0.03	0.00	0.02
8–10%	0.01	0.01	0.02	0.01	0.02	0.01
10–14%	0.01	0.01	0.01	0.02	0.01	0.03
>14%	0.01	0.01	0.01	0.01	0.01	0.00

SOURCES: Federal Financial Institutions Examination Council, Quarterly Reports on Income and Condition; and authors' calculations.

bank portfolio changes. In particular, the changes emerge more clearly when the phase-in of the new regulations began rather than at the time they were announced. Two reasons account for this delay: First, risk-based capital requirements represented a radical change in U.S. banking regulation, so a period of learning about their consequences is not surprising. Second, if portfolio changes were made to improve banks' capital position, they were not necessary until the phase-in began. In addition, government security portfolios can be changed quickly and easily.

The ANOVA significance tests suggest that there are important differences across asset ratio categories, but do not imply any particular direction in the relationship. For the four asset categories with significant differences across capital–ratio classes, we show the actual mean changes in each capital class for the two-and-a-half-year period after the introduction of risk-based capital requirements in table 6.

The evidence is clear for both government securities and C&I loans. The extent to which the ratio of government bonds to assets increased diminishes as the initial capital position of the bank improves. In fact, in four of the six size groups, the extremely well-capitalized banks (capital ratios greater than 14 percent) did not even boost their holdings of government securities. The evidence for C&I loans is equally compelling. Banks in all categories decreased their portfolio share in C&I loans. In each size class, the fall in the C&I loan share was larger for the poorly capitalized banks.

For banks with initial total-to-risk-adjusted capital of less than 8 percent, the share of government securities in total assets increased on average by 4 percentage points, and the share of C&I loans in total assets decreased by 4 percentage points. Thus, there is a strong indication that poorly capitalized banks responded to the new capital requirements by shifting from C&I loans to government securities. Because the movement away from C&I loans is at least partially due to the deteriorating quality of loan portfolios, it is important to see if the results are robust when we hold the quality of the portfolio constant. The mortgage results are more ambiguous, as expected. With a 50-percent risk weight, they fall between commercial loans and Treasury securities.

Tables 5 and 6 do not completely make the case that a greater portfolio shift took place among undercapitalized banks. The F-test suggests that the means differ, and the means themselves show greater portfolio shifts for un-

TABLE 7

Tukey Multiple Comparison Tests for Differences in Means

A. Total Securities
Alpha = 0.05, Confidence = 0.05,
Degrees of Freedom = 10861,
Mean Square Error = 0.009487,
Critical Value of Studentized Range = 3.858.

Capital Classes Compared		Simultaneous Lower Confidence Limit	Difference between Means	Simultaneous Upper Confidence Limit
0	1	−0.062459	−0.008804	0.044850
0	2	−0.046423	0.005599	0.057620
0	3	−0.039369	0.011973	0.063316
0	4	−0.019429	0.031819	0.083068
1	0	−0.044850	0.008804	0.062459
1	2	−0.004421	0.014403	0.033228
1	3	0.003920	0.020778	0.037635[a]
1	4	0.024055	0.040624	0.057192[a]
2	1	−0.033228	−0.014403	0.004421
2	0	−0.057620	−0.005599	0.046423
2	3	−0.004188	0.006375	0.016937
2	4	0.016125	0.026220	0.036316[a]
3	1	−0.037635	−0.020778	−0.003920[a]
3	0	−0.063316	−0.011973	0.039369
3	2	−0.016937	−0.006375	0.004188
3	4	0.014214	0.019846	0.025477[a]
4	1	−0.057192	−0.040624	−0.024055
4	0	−0.083068	−0.031819	0.019429
4	2	−0.036316	−0.026220	−0.016125[a]
4	3	−0.025477	−0.019846	−0.014214[a]

B. Treasury Book
Alpha = 0.05, Confidence = 0.95,
Degrees of Freedom = 10861,
Mean Square Error = 0.005965,
Critical Value of Studentized Range = 3.858.

Capital Classes Compared		Simultaneous Lower Confidence Limit	Difference between Means	Simultaneous Upper Confidence Limit
0	1	−0.028772	0.013774	0.056321
0	2	−0.018189	0.023062	0.064313
0	3	−0.011794	0.028919	0.069632
0	4	0.003935	0.044573	0.085211[a]
1	0	−0.056321	−0.013774	0.028772
1	2	−0.005640	0.009287	0.024215
1	3	0.001777	0.015145	0.028512[a]
1	4	0.017660	0.030799	0.043937[a]
2	0	−0.064313	−0.023062	0.018189
2	1	−0.024215	−0.009287	0.005640
2	3	−0.002518	0.005857	0.014233
2	4	0.013506	0.021511	0.029516[a]
3	0	−0.069632	−0.028919	0.011794
3	1	−0.028512	−0.015145	−0.001777[a]
3	2	−0.014233	−0.005857	0.002518
3	4	0.011188	0.015654	0.020120[a]
4	0	−0.085211	−0.044573	−0.003935[a]
4	1	−0.043937	−0.030799	−0.017660[a]
4	2	−0.029516	−0.021511	−0.013506[a]
4	3	−0.020120	−0.015654	−0.011188[a]

a. Significant at the 0.05 percent level.
SOURCE: Authors' calculations.

dercapitalized banks, but neither approach indicates which means differ from which other means. To do so properly requires a multiple comparison procedure, which introduces a complication. The significance level (say 0.05) of the standard t- and F-tests applies only to that particular test, and not to a series of tests. Thus, it would be inappropriate to use the standard t-test to determine if the mean of capital class 1 *and* capital class 2 differed from the mean of capital class 6. The standard statistic is further inappropriate if the comparison is suggested by the data, say comparing the highest and the lowest means. For example, in comparing the highest and lowest means, with six classes the standard 5 percent test is in fact a 60 percent test (Neter and Wasserman [1974], section 14.2). Table 7 corrects for these problems by using the Tukey method for multiple comparison, which is based on the studentized range distribution (see Neter and Wasserman [1974], section 14.3, and SAS/STAT User's Guide [1990], volume 2, chapter 24). For example, the first line of table 7 compares the mean change in the proportion of total securities for capital class 0 with the same mean for capital class 1.

TABLE 7 (CONT.)

Tukey Multiple Comparison Tests for Differences in Means

C. Total Loans
Alpha = 0.05, Confidence = 0.95,
Degrees of Freedom = 10861,
Mean Square Error = 0.008611,
Critical Value of Studentized Range = 3.858.

D. C&I Loans
Alpha = 0.05, Confidence = 0.95,
Degrees of Freedom = 10861,
Mean Square Error = 0.002579,
Critical Value of Studentized Range = 3.858.

Capital Classes Compared		Simultaneous Lower Confidence Limit	Difference between Means	Simultaneous Upper Confidence Limit	Capital Classes Compared		Simultaneous Lower Confidence Limit	Difference between Means	Simultaneous Upper Confidence Limit
0	4	−0.103050	−0.054225	−0.005401[a]	0	4	−0.0656967	−0.0389768	−0.0122569[a]
0	3	−0.071166	−0.022252	0.026663	0	3	−0.0514908	−0.0247219	0.0020471
0	2	−0.046760	0.002801	0.052363	0	1	−0.0409112	−0.0129366	0.0150380
0	1	−0.038886	0.012231	0.063349	0	2	−0.0398953	−0.0127722	0.0143508
1	4	−0.082242	−0.066457	−0.050672[a]	1	4	−0.0346787	−0.0260402	−0.0174016[a]
1	3	−0.050543	−0.034483	−0.018423[a]	1	3	−0.0205744	−0.0117853	−0.0029961[a]
1	0	−0.063349	−0.012231	0.038886	1	2	−0.0096505	0.0001644	0.0099792
1	2	−0.027364	−0.009430	0.008504	1	0	−0.0150380	0.0129366	0.0409112
2	4	−0.066644	−0.057027	−0.047409[a]	2	4	−0.0314679	−0.0262045	−0.0209411[a]
2	3	−0.035116	−0.025053	−0.014990[a]	2	3	−0.0174567	−0.0119496	−0.0064426[a]
2	0	−0.052363	−0.002801	0.046760	2	1	−0.0099792	−0.0001644	0.0096505
2	1	−0.008504	0.009430	0.027364	2	0	−0.0143508	0.0127722	0.0398953
3	4	−0.037339	−0.031974	−0.026608[a]	3	4	−0.0171911	−0.0142549	0.0113187[a]
3	0	−0.026663	0.022252	0.071166	3	1	0.0029961	0.0117853	0.0205744[a]
3	2	0.014990	0.025053	0.035116[a]	3	2	0.0064426	0.0119496	0.0174567[a]
3	1	0.018423	0.034483	0.050543[a]	3	0	−0.0020471	0.0247219	0.0514908
4	3	0.026608	0.031974	0.037339[a]	4	3	0.0113187	0.0142549	0.0171911[a]
4	0	0.005401	0.054225	0.103050[a]	4	1	0.0174016	0.0260402	0.0346787[a]
4	2	0.047409	0.057027	0.066644[a]	4	2	0.0209411	0.0262045	0.0314679[a]
4	1	0.050672	0.066457	0.082242[a]	4	0	0.0122569	0.0389768	0.0656967[a]

a. Significant at the 0.05 percent level.
SOURCE: Authors' calculations.

The difference between the means is positive, but the confidence limits include 0, so we cannot reject equality of the means.

The results in table 7 confirm the significance of the portfolio change. The undercapitalized banks shifted toward securities and away from loans more than did the adequately capitalized and well-capitalized banks.

But another possibility is yet unaccounted for. Low-capitalized banks might have different portfolio shifts even without a change in capital requirements. For example, suppose a bank has low capital because of takedowns of loan commitments that had been funded by purchased money. That is, the bank ends up with an unexpectedly high proportion of loans. Over time, the bank might lower its loan level to restore the desired balance between loans and securities. We wish to demonstrate that low-capital banks do not normally increase their securities holdings in the years following a change in requirements.

To provide some evidence on this, we compare the behavior of banks from 1988 to 1990 with their behavior from 1990 to 1992. Specifically, we compare the portfolio changes in low-

TABLE 8

ANOVA Comparison of Portfolio Shifts between Periods

Capital Class	Asset Components 1988–90	1990–92
	Cash	
0–4%	0.001 (0.044)	−0.003 (0.031)
4–8%	−0.015 (0.047)	−0.010 (0.047)
8–10%	−0.012 (0.035)	−0.010 (0.039)
10–14%	−0.016 (0.045)	−0.013 (0.042)
>14%	−0.019 (0.050)	−0.015 (0.050)
	Government Securities	
0–4%	−0.003 (0.037)	0.046 (0.099)
4–8%	−0.003 (0.048)	0.032 (0.068)
8–10%	−0.001 (0.042)	0.032 (0.057)
10–14%	−0.004 (0.046)	0.017 (0.067)
>14%	−0.014 (0.065)	0.001 (0.085)
	C&I Loans	
0–4%	−0.038 (0.069)	−0.047 (0.072)
4–8%	−0.017 (0.062)	−0.035 (0.060)
8–10%	−0.019 (0.059)	−0.035 (0.061)
10–14%	−0.012 (0.051)	−0.023 (0.056)
>14%	−0.002 (0.040)	−0.008 (0.046)
	Mortgages	
0–4%	0.013 (0.065)	−0.006 (0.062)
4–8%	0.007 (0.042)	0.014 (0.067)
8–10%	0.007 (0.050)	0.013 (0.065)
10–14%	0.005 (0.043)	0.012 (0.053)
>14%	0.007 (0.039)	0.014 (0.051)

NOTE: Standard deviations are in parentheses.
SOURCE: Authors' calculations.

capital banks from 1988 to 1990 with portfolio changes in all other banks from 1990 to 1992 and with low-capital (as of 1990) banks from 1990 to 1992. By using this method, we control for portfolio shifts due to both macroeconomic effects and low capitalization.

Table 8 reports these results. Capital requirements certainly appear to have had an impact. Across each capital class, banks reduced their C&I loans more from 1990 to 1992 than from 1988 to 1990. Low-capital banks even *decreased* their bond holdings in the earlier period, but raised them in response to capital requirements from 1990 to 1992. A large caveat goes along with this work, however, in that most of the differences (even between negative and positive terms) are not statistically significant, even at the 10 percent level.

V. Regression Analysis

We examine the influence of deterioration in the quality of the loan portfolio on bank portfolio allocation changes with a regression model that is a simple extension of the ANOVA framework. The regression equation includes dummy variables for each of the size and capital classes and a measure of the quality of the i^{th} bank's loan portfolio:

$$\Delta \text{ asset ratio}_i = \alpha + \Sigma\, \beta_j \text{ size dummies}_i + \Sigma\, \gamma_k \text{ capital dummies}_i + \delta \text{ loan quality}_i .$$

The charge-off ratio (as of March 1990) — the ratio of net charge-offs to assets — is used to measure loan quality.

A summary of the regression results for the asset ratio changes between 1990 and 1992 for each category is presented in table 9. The charge-off rate has a significant influence on each asset category. The largest effects of poor loan quality are on the increase in Treasury securities and on the decrease in real estate loans. In both of these instances, a 0.5 percentage-point increase in the charge-off ratio (which is about equal to the increase in the aggregate ratio over the 1980s, as shown in figure 4) results in an absolute change in the asset ratio of about 0.01 percentage point. Significant differences between size classes and capital classes appear in all but one category. Finally, the regressions explain only a small proportion of the interbank variation in asset ratios.

The bottom part of table 9 shows the estimated coefficients for the capital dummies. They represent differences from the omitted category: banks with initial risk-adjusted capital ratios in excess of 14 percent. The relationship between the initial capital position and the extent to which the bank increased government securities holdings and reduced loans is still substantial. That is, even with the influence of the quality of the loan portfolio held constant, poorly capitalized banks made large portfolio adjustments away from both C&I and real estate loans and toward holdings of government securities.

TABLE 9

Summary of Regression Results

	Coefficient and t-statistic	F-test Probability		
	Charge-Off Ratio	Size Dummies	Capital Dummies	R^2
Cash assets	0.051	0.3592	0.0499	0.002
	(2.1)			
Total securities	4.60	0	0	0.028
	(9.2)			
Treasuries	2.78	0	0	0.021
	(7.0)			
Other loans	1.83	0.0002	0.6557	0.004
	(3.7)			
Total loans	−5.06	0	0	0.068
	(10.6)			
C&I loans	−0.86	0	0	0.038
	(3.3)			
Mortgages	−0.009	0.635	0.163	0.002
	(3.4)			
Other loans	−0.03	0	0	0.032
	(8.1)			

Capital Dummy Coefficients
(Difference from omitted category — Ratio >14%)

	0–4%	4–8%	8–10%	10–14%
Cash assets	0.01	0.00	0.00	0.00
Total securities	0.03	0.03	0.02	0.02
Treasuries	0.04	0.02	0.02	0.01
Other loans	−0.01	0.01	0.00	0.00
Total loans	−0.05	−0.05	−0.04	−0.03
C&I loans	−0.04	−0.02	−0.02	−0.01
Mortgages	−0.02	−0.02	−0.00	−0.02
Other loans	0.01	−0.03	−0.02	−0.01

NOTE: Standard deviations are in parentheses.
SOURCE: Authors' calculations.

VI. Conclusion

The evidence presented here strongly suggests that bank portfolio changes since 1990 are at least in part a response to the introduction of risk-based capital requirements. Qualitatively, at least, the regulations succeeded. Comprehending the changes improves our general understanding of the effects of bank regulation. The particular effect of capital requirements on bank portfolios merits special interest. The shift in bank portfolios can affect their overall risk, and therefore the risk of financial collapse and the liability of the federal government acting as the lender of last resort. On the other hand, the reduction in loans may (under the "credit view") have macroeconomic consequences and reflect on overall economic growth, income, and unemployment.[11]

■ **11** The credit view argues that changes in bank lending—and in credit more generally—have an important effect on the aggregate economy above and beyond any effect on the money supply.

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